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Haugbølle, Kim

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# Changing construction: Perspectives on knowledge and learning

Kim Haugbølle,  
Danish Building Research Institute, Aalborg University  
khh@sbi.aau.dk

## Abstract

The problem of knowledge in construction is not ‘just’ about knowledge, but about learning and about putting knowledge into action in order to change practices. This paper will use the Danish knowledge system as a case study in order to analyse where and why problems with regard to knowledge occur in construction. This analysis is based on a literature review of seminal studies on knowledge in general and a comprehensive documentary analysis of policy studies on the Danish knowledge system combined with qualitative research interviews of key persons. This paper starts out with a brief exploration of Danish policy studies and initiatives on knowledge and learning in construction. The paper then moves on to outline an analytical framework to understand knowledge and learning within construction. This paper suggests that an analytical framework should: 1) adopt a systemic perspective on construction and refurbishment, 2) highlight the absorptive capacity of firms as a crucial concept for adopting new knowledge, 3) be sensitive to the historicity and path-dependency of the individual construction project, 4) embrace communities of practice as the key framework for learning; and 5) manage the recurrent changes in knowledge types during construction projects, notably from tacit to explicit knowledge and vice versa. Based on this analytical framework, this paper has in broad terms analysed how the various Danish policy studies of the knowledge system have articulated the problem of knowledge in construction, identified how these articulations become controlling of the corresponding solutions, and pointed out some of the shortcomings as a result. With these insights in mind, it is the hope that future studies and public policies will adopt a more reflexive and reflective approach to the problem of knowledge in construction.

**Keywords:** Knowledge flows, bounded rationality, governance, social shaping, communities of practice

# 1. Introduction: A sticky problem

Knowledge or rather the lack of knowledge-sharing has frequently been evoked as a core problem with regard to improving the sustainability, performance and productivity of construction. Hence, a range of policy analyses along with development initiatives and research studies have been conducted over the years in Denmark. The policy analyses include for example the use of technological services in construction (Bang, 1997), a survey on learning and knowledge (Alsted Research, 2003), the characteristics of the communication landscape in construction as formulated by the development programme Project House (Christoffersen, 2000) and the repeated call for improved dissemination of building knowledge (see e.g. Carlsen et al., 2005). A number of other policy studies have focused on activities related to research and development in construction. These include among others an analysis by the Danish Building Development Council (abbreviated BUR) on production, use and dissemination of technical building knowledge (Dræbye, 1997) and several mappings of construction-related research and development activities (see e.g. Christoffersen and Bertelsen, 1990; Boligministeriet, 1993; Det Offentlige Forskningsudvalg for Byer og Byggeri (translation: The Public Research Committee on Cities and Construction), 2000; Haugbølle and Clausen, 2002). These have been followed by a number of public action plans like the programme ‘The Future of Construction: From tradition to innovation’ (By- og Boligministeriet & Erhvervsministeriet, 2000), the action plan on research and development activities (Udvalget vedrørende byggeforskning i Danmark (translation: Committee on Construction Research in Denmark), 2002), and a proposal for strengthening research and learning in construction issued jointly by the industry, government and knowledge institutions (Koordinations- og initiativgruppen for viden i byggeriet, 2009).

Along with the long line of policy studies a number of experiments and development activities have been carried out, which have pointed at possible ways to improve the dissemination and sharing of knowledge in particular with regard to the use of new information and communication technologies (ICT). These experiments and development activities include among others the Tele-byg project on the use of virtual communication in long-distance consultancy (Hansen et al., 2002) as well as the MELFO and Melfa projects on the use of handheld devices (PDA or smart phones) to support mobile e-learning for dyslexics. A number of initiatives like the BygSol programme (Christensen, 2008) and Bricklayers in Motion (see e.g. Bertelsen, 2011) have also been targeted at developing vocational training and improving the competences of craftsmen and unskilled labour. The construction-related research on knowledge include among others studies of morality and knowledge production among consulting engineers (Munch, 2005), the cultural organisation in construction and its role in knowledge application (Thuesen, 2006) and the constitution of partnering (Gottlieb, 2010). In recent years, extensive efforts have also been put into developing and applying Building Information Modelling (BIM) among Danish consultants in particular and more lately Virtual Design and Construction (VDC) among some of the major Danish contractors.

Despite all of these efforts, the “problem of knowledge” seems not only to be sticking around, but also to be accentuated by a general shift in most industrialised countries from new construction towards refurbishment activities. Refurbishment entails a different set of

challenges compared to new construction, which calls for new strategies, knowledge and development of practices among construction professionals, policy makers and knowledge institutions. Hence, a range of new initiatives are being launched to address these challenges in many countries like the UK Green Deal programme, the Belgian BrusselsRetrofitXL programme and the European roadmap for moving to a low-carbon economy by 2050 (European Commission, 2011).

Denmark is no exception to this general line of development. Thus, two large private foundations recently initiated and funded a think tank to develop a new comprehensive refurbishment strategy for the built environment. The think tank was composed of some 30 members representing all major parties of the built environment. Over the course of a year the think tank held a number of consultations with experts, professionals and policy makers to identify relevant challenges and formulate corresponding initiatives to address these. At the end of 2012, the think tank published its strategy with seven initiatives related among others to improving statistics on refurbishment, accelerating innovation, strengthening education and improving dissemination of knowledge (Tænketank for bygningsrenovering, 2013).

One of the ensuing initiatives encompassed a more substantial analysis of ‘the problem of knowledge’. This chapter will report on the results of this analysis and take a closer look at where and why problems occur with regard to knowledge within construction. It will take as its starting point that the problem of knowledge is not ‘just’ about knowledge, but about learning and about putting knowledge into action in order to transform practices. The chapter will identify different perspectives on knowledge and discuss how these understandings and metaphors of knowledge articulate knowledge differently as a problem and thus becomes controlling of the corresponding solutions.

## **2. Methodology**

### **2.1 Ontological position**

The analytical framework of this paper is developed on the basis of a number of seminal studies on knowledge in general. The ontological position is based on the following assumptions about knowledge in construction and refurbishment, more specifically:

- An analytical framework needs to address five levels to give a comprehensive understanding of the problem of knowledge in construction. These five levels are: 1) construction as a system, 2) firms as key players, 3) projects as the focal point, 4) communities of practice in groups and professions, and 5) individuals as bearers of skills.
- An analytical framework of knowledge in construction needs to be able to include both explicit and tacit knowledge as both forms are strongly prevalent among the different actors of construction.

- An analytical framework needs to acknowledge that knowledge-sharing among project participants and dissemination of knowledge from e.g. development projects takes place through many different means depending on the type of knowledge etc.
- An analytical framework needs to consider knowledge as functional rather than actor-centred, i.e. production, distribution and use of knowledge is not exclusively linked to the different type of actor, but all actors may to a varying degree over time and space act as producers, intermediaries and users of knowledge.
- An analytical framework needs to recognise that the formulation of knowledge problems and possible solutions to these problems of knowledge is largely dictated by how knowledge in construction is perceived and conceptualised.

## 2.2 Research design

The research design follows a case study design. Flyvbjerg (2006: 230) states that paradigmatic cases '*develop a metaphor or establish a school for the domain that the case concerns.*' Identifying a case as paradigmatic is particularly challenging as noted by Flyvbjerg (2006: 232) as paradigmatic cases by their very nature transcends any sort of rule-based criteria. The analysis of the Danish knowledge system on construction and refurbishment may be considered paradigmatic in the sense that it shares a number of characteristics and similarities with other industrialised countries e.g. with regard to the distribution of construction output as new built versus refurbishment, the application of the same European rules of procurement, and the use of a range of similar construction products as in many other countries due to the European internal market. However, there are a number of differences in national building codes, industrial structure etc. that makes it less likely to use the Danish knowledge system as an exemplar for construction knowledge systems in general.

The case also have elements of being a critical case, which makes it possible to draw conclusions or generalisations of the kind that '*if it is valid for this case, it is valid for all (or many) cases*' (Flyvbjerg, 2006: 230). These arguments relate to characteristics of the Danish construction industry like Danish construction professionals being generally considered as highly skilled and knowledgeable, a well-paid workforce with social status, high degree of digital literacy and extensive access to ICT solutions. Hence, if problems of knowledge exist in the Danish construction industry, the same kind of problems – and maybe even in an accentuated form – are likely to be found in other national construction industries.

## 2.3 Methods and data

The study is based on a documentary analysis combined with qualitative research interviews. The longitudinal documentary analysis is based on a comprehensive selection of written Danish sources covering the most prominent policy studies etc. over a period of over more than two decades. This longitudinal study has been combined with a cross-sectional study of the present situation and challenges through qualitative research interviews with seven key persons representing major actors of the construction industry. These include a representative from

educational institutions, information offices, research institutions, contractors, trade unions, wholesalers, and R&D funding offices.

### 3. The problem of knowledge in construction

#### 3.1 A systemic perspective

Gann and Salter (2000) adopt a systemic perspective on construction, where innovation must be understood in the context of both the technological support infrastructure for producing knowledge and the regulatory and institutional environment. The individual elements of the system are connected to each other through flows of knowledge. Haugbølle et al. (2012) has developed Gann and Salter (2000) systemic perspective to also explicitly include the building users and suggest that links between the individual element can predominantly be understood as business processes between actors in three different types of markets, learning processes and policy processes (see Figure 1).

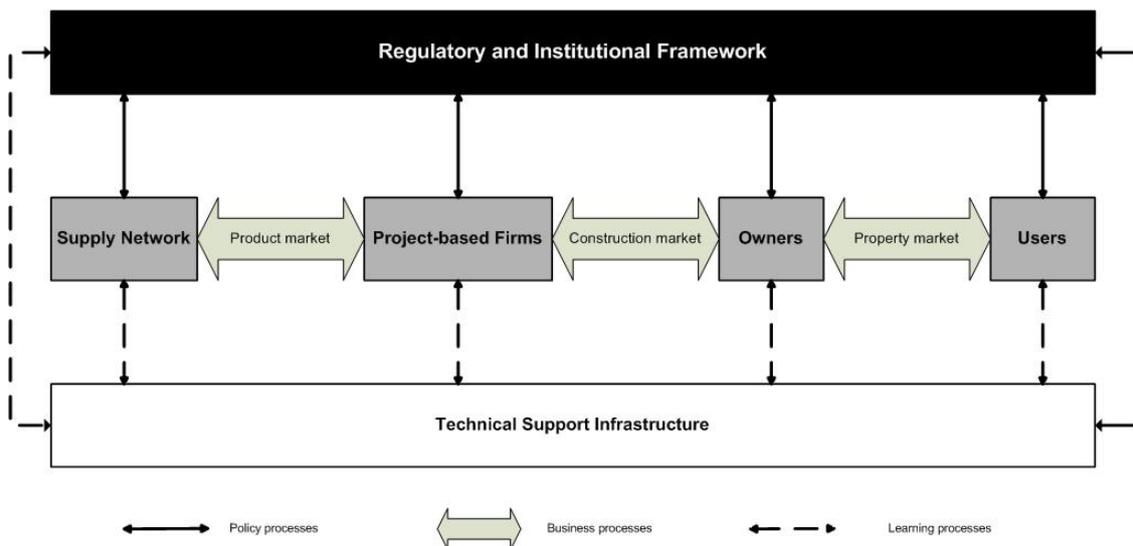


Figure 1: Systemic perspective on construction (Haugbølle et al., 2012: 452)

The majority of policy studies on the problem of knowledge in Danish construction have focused on how new research-based knowledge can be made available for use in the project-based companies of construction. Most of these policy studies criticise in particular the universities and other knowledge institutions for not disseminating new knowledge appropriately to the project-based firms of construction, in particular contractors and consultants. Thus, the preferred solution to the knowledge problem is to improve dissemination from the universities and the like through e.g. mandatory dissemination plans for R&D projects, joint information services e.g. as a sort of digital one-stop-shopping solutions etc.

However, a systemic perspective on the problem of knowledge as mentioned above indicates that it is far too narrow to focus on the dissemination from knowledge institutions. A systemic

perspective would rather suggest that the problem of knowledge can be found in four different locations:

- The interaction between the political-institutional apparatus on one side and business as well as users on the other side.
- The interaction between the individual companies and its customers throughout the entire supply chain spanning three separate markets of products, construction and property.
- The interaction between knowledge institutions and each of the business actors – supply network, project-based firms, owner and users of buildings.
- The capabilities and interaction within each of the individual units.

### **3.2 Firm versus project: Absorptive capacity**

Especially the capabilities and interaction within each organisation has often been neglected in Danish policy studies, even though this is central to a firm's ability to adopt new knowledge. A central key concept in this context is 'absorptive capacity'. Cohen & Levinthal (1990: 128) defines this ability to absorb knowledge in the following way:

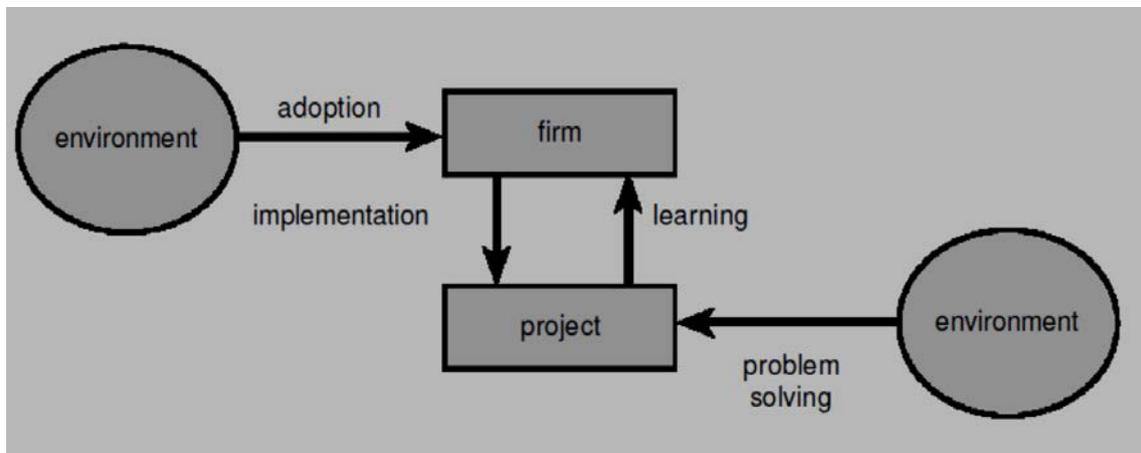
*'...the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities. We label this capability a firm's absorptive capacity and suggest that it is largely a function of the firm's level of prior related knowledge.'*

The development of a firm's absorptive capacity depends on both the individual's and the organisation's ability to adopt knowledge, which is both history-dependent and path-dependent. Cohen & Levinthal (1990: 132) further point out that the firm's ability to adopt new knowledge depends on the communicative structures inside and outside the firm, including the nature and distribution of expertise within the organisation:

*'Absorptive capacity refers not only to the acquisition or assimilation of information by an organization but also to the organization's ability to exploit it. Therefore, an organization's absorptive capacity does not simply depend on the organization's direct interface with the external environment. It also depends on transfers of knowledge across and within subunits that may be quite removed from the original point of entry. Thus, to understand the sources of a firm's absorptive capacity, we focus on the structure of communication between the external environment and the organization, as well as among the subunits of the organization, and also on the character and distribution of expertise within the organization.'*

In project-based industries like construction, the absorptive capacity is not solely linked to the firm as such, but as well to the often many projects being managed by the firm simultaneously and over time. Hence, the interplay between the firm as the basis and the individual projects as well as across projects is crucial for understanding and dealing with the problem of knowledge

in construction. In his earlier work with innovation in the project-based organisations of construction, Winch (1998) has suggested the following model for different types of knowledge flows between the project, the firm and the surroundings of both (see Figure 2).



*Figure 2: Knowledge flows between project and firm (Winch, 1998: 273)*

The model is a reminder that the problem of knowledge must be addressed along at least three dimensions:

- External to the firm – either horizontally in networks with like-minded people for example within the same profession or vertically in networks across disciplines.
- In-between the individual projects and the firm.
- Within the project between the respective project participants, but external to the firms involved in a project.

What the model however fails to acknowledge is the need to address the knowledge flows taking place between different projects either simultaneously in time or consecutively over time.

### **3.3 No project is an island: Historicity and path dependency**

Projects are not only vital for both new construction and refurbishment but the very organising principle of construction firms. The uniqueness of projects is often used as an explanation for why it is difficult to share knowledge and create change in construction. Despite the widely held assumption of projects being both unique and isolated events, projects are not isolated islands as Engwall (2003) points out. Instead projects are embedded in an organisational context and with a historicity marked by previous projects, parallel courses of events and ideas about the post-project future.

Following Engwall (2003), knowledge in projects is not isolated or necessarily unique, but is tied up on experience from previous projects as well as project-independent factors such as general business policies that go beyond the individual project. In this way, previous experience and general policies creates a path dependency that sets the scene for future projects (Figure 3).

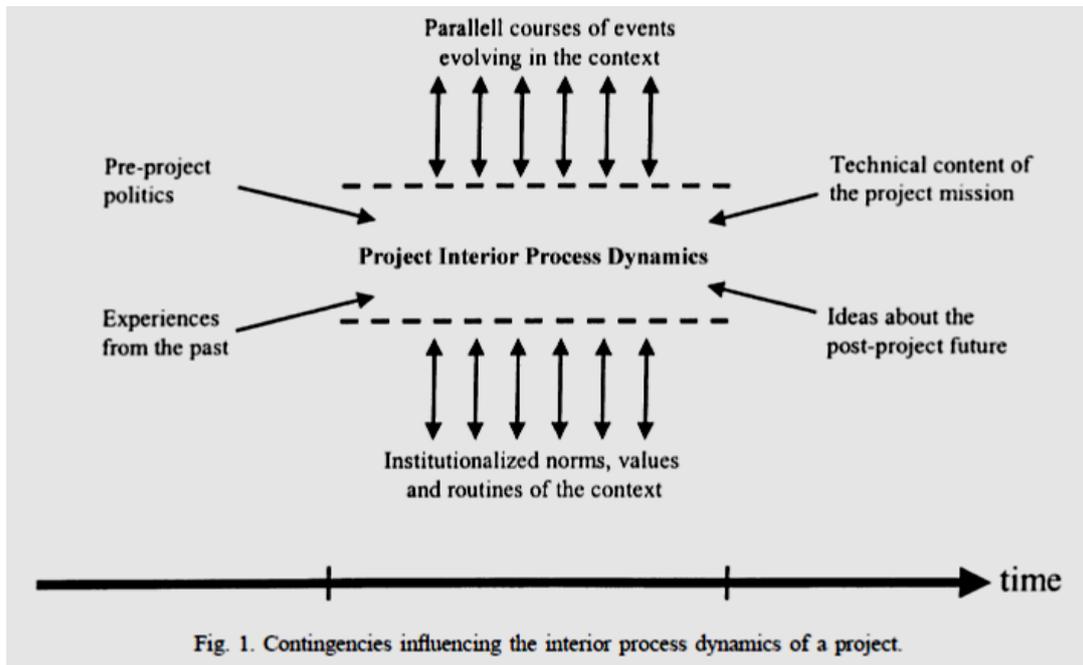


Figure 3: Factors affecting the project's dynamics (Engwall, 2003: 805)

In most Danish policy studies there is a strong rhetoric on the project-based nature of construction and the barriers to knowledge and change created by this very nature. However, a range of possible interventions related to the contingencies influencing the interior process dynamics of a project tend to be ignored. While these contingencies may be overlooked in policy studies, some of the major Danish consulting firms and contractors now attempt to address these in their internal training and course activities on management. But management and learning within and across projects is only side of the knowledge problem in construction. Another side of the problem is related to how trades and professions operate and are organised.

### 3.4 Learning: Communities of practice

Collaboration, knowledge-sharing and learning across the many trades and professions within construction is notoriously challenging as have been recognised by several (see e.g. Christensen, 2008 and Thuesen, 2007). But these shared communities of practice within trades and professions also hold strong a potential for being a part of the solution to (part of) the problem of knowledge in construction.

Communities of practice have in recent years received considerable attention in the context of organisational development and efforts to understand and improve knowledge and improve learning in organisations. Wenger (1998: 4-5) defines learning as an active participation in the practices of a community and forming of identity in relation to these communities:

*‘A social theory of learning must therefore integrate the components necessary to characterize social participation as a process of learning and of knowing. These components (...) include the following:*

- 1) Meaning: a way of talking about our (changing) ability – individually and collectively – to experience our life and the world as meaningful.*
- 2) Practice: a way of talking about the shared historical and social resources, frameworks, and perspectives that can sustain mutual engagement in action.*
- 3) Community: a way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence.*
- 4) Identity: a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities.’*

With regard to innovation and change management, the problem of knowledge in Danish construction projects is not only a matter of learning new things, but also to ‘unlearn’. The ability to discard knowledge – where appropriate – is also an important aspect of communities of practice, although this is often overlooked.

Knowledge and learning across communities of practice like trades and professions within construction presents challenges because of the very characteristics that are also their strengths, i.e. the internal autonomy of the communities, their informal nature, and not least their differences in prevalence of knowledge types.

### **3.5 Tacit versus explicit knowledge: Repeated shifts**

Knowledge management deals with collecting, developing, distributing and applying knowledge in organisations. One of the most important and seminal work was done by Nonaka and Takeuchi (1995), who studied knowledge and innovation in Japanese companies and developed the so-called SECI model. The SECI model analyses the interaction and transformations between tacit and explicit knowledge. The SECI model points out that both forms of knowledge are important and that the conversion between them is important (see Figure 4).

		TO	
		Tacit knowledge	Explicit knowledge
FROM	Tacit knowledge	Socialization	Externalization
	Explicit knowledge	Internalization	Combination

*Figure 4: The SECI model – four types of conversion of knowledge (Adapted after Nonaka & Takeuchi, 1995: 62)*

The construction process is typically characterised by the involvement of several firms and trades, which implies numerous and repeated shifts between tacit knowledge and explicit knowledge. The ability to handle these shifts in order to accumulate, disseminate and apply knowledge in practice is probably one of the construction industry's main challenges with regard to knowledge. As pointed out bluntly by Danish practitioners: First, the client must articulate his tacit and more or less explicit knowledge about his needs for a new building. The consultant then turns these into to explicit knowledge in the shape of formal documents such as drawings and specifications. This explicit knowledge is then being adopted and adapted to tacit knowledge, which is the primary knowledge base among the craftsmen in construction companies. Finally, the actual building will be managed by building caretakers based on their mix of explicit and tacit knowledge on caretaking of that particular building, and it will be measured against the more or less tacit knowledge of the end-users of how appropriate the services delivered by the building suits their needs.

## 4. Conclusions

This paper has provided a brief exploration of an extensive number of Danish policy studies and initiatives on knowledge and learning in construction over the past two decades.

The paper then moved on to outline an analytical framework to understand knowledge and learning within construction. This paper suggests an analytical framework that: 1) adopt a systemic perspective on construction, 2) highlight the absorptive capacity of firms as a crucial concept for adopting new knowledge, 3) is sensitive to the historicity and path-dependency of the individual construction project, 4) embrace communities of practice as the key framework for learning; and 5) manage the recurrent changes in knowledge types, notably from tacit to explicit knowledge and vice versa.

Based on this analytical framework, this paper has in broad terms analysed how the various Danish policy studies of the knowledge system have articulated the problem of knowledge in construction, identified how these articulations become controlling of the corresponding solutions, and pointed out some of the shortcomings as a result. With these insights in mind, it is the hope that future studies and public policies will adopt a more reflexive and reflective approach to the problem of knowledge in construction.

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